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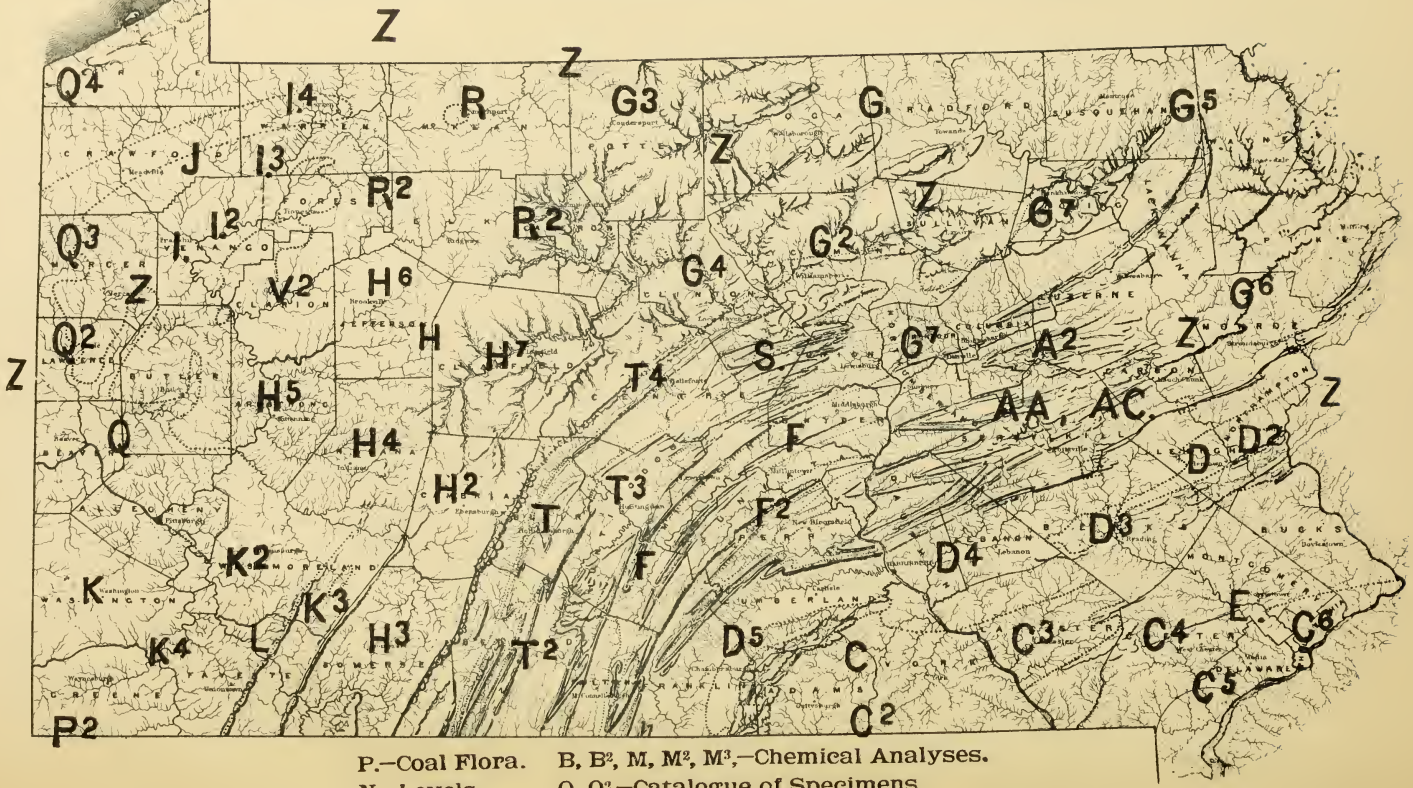

P.—Coal Flora. B, B², M, M², M³,—Chemical Analyses.
N.—Levels. O, O²,—Catalogue of Specimens.

SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA.

REPORT OF PROGRESS.

PPP.

CERATIOCARIDÆ

FROM THE

UPPER DEVONIAN MEASURES

IN WARREN COUNTY,

BY

CHAS. E. BEECHER.

With 2 plates.

EURYPTERIDÆ

FROM THE

LOWER PRODUCTIVE COAL MEASURES

IN BEAVER COUNTY,

AND THE

LOWER CARBONIFEROUS, PITHOLE SHALE,
IN VENANGO COUNTY,

BY

JAMES HALL.

With 6 plates.

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LETTER OF TRANSMITTAL.

To His Excellency Governor ROBERT E. PATTISON, *Chairman of the Board of Commissioners of the Second Geological Survey of Pennsylvania:*

SIR: I have the honor to present two reports on certain fossil forms found in Warren, Venango, and Beaver counties, one by Mr. Charles E. Beecher, formerly of Warren, now of Albany, N. Y., and the other by our distinguished American palæontologist, Prof. James Hall, of Albany, who, when other opportunities failed, kindly volunteered to study and describe the remarkable crustacean animals obtained by the Hon. I. F. Mansfield, in past years, from his coal mine workings at Cannelton.

Mr. Beecher's figures, drawn by himself, were lithographed by Breuker & Kessler, of Philadelphia.

Mr. Mansfield's specimens, exquisitely drawn by Mr. George B. Simpson, have been reproduced in fac simile by a heliotype process in Boston.

The Second Geological Survey of Pennsylvania was planned and has been prosecuted with a primary view to the material interests of the Commonwealth, the practical study of the rocks, their structure and mineral contents, and to as perfect a description of them as a diligent survey of facts could afford, with maps and sections and occasional photographic views for illustration; and I am happy to know that this conception of the proper nature of a State Survey has been approved by the Board of Commissioners, without reserve; and has been accepted with satisfaction also by intelligent citizens of the State, whether interested in the acquisition of such knowledge by possessing lands, or desirous of acquiring it as preparatory to exploring or mining lands.

But the education of a people cannot be confined within business limits. The learning of mere facts cannot advance the discipline of minds beyond a certain point. A truly intelligent people wishes to know the causes of facts, the reason of things, their relationships, their history, the logical conclusions of every kind which can be drawn from them by investigation. What is called modern science is the endeavor to satisfy this craving of human intelligence for something more and something nobler than mere facts,—the instinctive conviction of our age that education must be not merely accurate but also wide; that it is shameful to be satisfied with mere details; that apparently useless truth is in its very nature delightful and elevating, and is sure to become, sooner or later, in these hands or in those, in one direction or another, and always unexpectedly, useful.

Therefore, while the plan of the Survey was practical, its geologists have always kept in view whatever could help to effect a thorough knowledge of the geology of the State; especially those vegetable and animal forms which are impressed upon or imbedded within the rock formations which underlie the soil.

But the publication of this branch of the geology of Pennsylvania has been delayed for various reasons—chiefly because the study and delineation of fossils demand the entire time and exclusive devotion of those who undertake it, and cannot be successfully carried on by a geologist who is commissioned to report on a large territory—to map an entire county—in one field season.

Secondly: The collection of fossils must go first,—their study and delineation is a tedious subsequent performance.

Thirdly: The world of fossils has become so vast and the number of geologists who devote themselves to its investigation is so limited, that it has become necessary to divide it up into many parts. The collections of deep sea soundings made by the British ship Challenger have been distributed for study to botanists and zoologists in every country in Europe, and even in America. So, in the study of fossil forms, Carboniferous plants are sent to one expert,

Cretaceous and Tertiary plants to another, Devonian plants to a third. Common forms of shells found in great numbers in some of our strata are recognized by every geologist; but whenever a new or comparatively rare form is discovered the specimen is sent to some palæontologist of acknowledged authority at whatever distance he may be from the place where the discovery is made; nor would any geologist attempt to describe it without reference to museum collections and plates in published memoirs. And the same is true of corals, of fish, of mammals. Mr. Mansfield has had to wait more than seven years to get his Eurypterids properly described and figured as they are in this report.

That the Survey has not been unmindful of its duty in regard to palæontology is shown by the publication of the admirable report on the Coal Flora of Pennsylvania and the United States by Mr. Lesquereux, who has been occupied ten years in its preparation and publication; * and by the report on the Permian plants of Greene county and West Virginia, by Prof. Wm. M. Fontaine and Prof. I. C. White. Prof. E. W. Claypole's report on Perry and Juniata counties and the fossils of Middle Pennsylvania, the fruit of three years' field and office work, is now ready to go to press. Prof. Angelo Heilprin, of Philadelphia, has volunteered a report on the Permian shells of Wilkes-Barre. And in the various reports of Prof. Stevenson and Prof. White will be found copious notes of the distribution of fossil forms through the column of rocks in their respective districts.

It must not be supposed, however, that the fossils of Pennsylvania have been adequately studied. In fact, their systematic study has but been begun. The patient field work which Prof. Claypole has expended upon the two counties of Perry and Juniata—or, rather, on parts of these two counties—must be bestowed on the other sixty-five counties of the State before it can be said that this part of the Geological Survey of Pennsylvania has been accomplished. A good beginning has certainly been made, but it

*Vol. III, with thirty new plates, new tables and a new index, is just issuing from the State printing house at Harrisburg.

will depend upon the intelligent interest of the citizens of the State whether or not the good beginning shall be prosecuted to a good end.

If the question of utility be raised; if it be asked—as it undoubtedly will be by the common run of business men—What is the use of such a report as the one I have now the honor to transmit to you? Why should the State expend the hard-earned money of its citizens in publishing drawings of strange creatures buried in the mud of ancient peat-bogs or in the sands of the sea bottom of ages long ago—creatures unlike any which now live, creatures belonging to an order of the world long since changed and done away—I have no definite answer to make to such a question. In a business sense it is of no use whatever, if one regards merely the facts drawn on the page plate. But even the merest business man will comprehend its utility, if he be interested in coal mines and can assure himself that the recognition of certain forms in one particular coal bed is likely to aid him in identifying that particular coal bed in other localities. The study of fossil shells found in formations beneath the coal measures is a really practical guide to certain limestone beds, and sometimes fixes in a very practical manner the order of rocks containing iron ore deposits, especially where downthrow faults have disturbed or concealed that order. If the location of mineral beds has anything to do with the order of formations, which no intelligent person questions, and if the study of fossils is a help in the study of the order of formations, which all geologists know to be true, then the Government is justified in ordering a complete survey of the fossils of the State, and the publication of their forms for the instruction of the people.

But apart from all money considerations, every plate of these extinct forms, so strange to living eyes, is a lesson for each and every man, enlarging the range of human education, and disciplining the intellect to the love and comprehension of the laws and forces of nature, so benificent to mankind.

J. P. Lesley.

Philadelphia, June 18, 1884.

CERATIOCARIDÆ

FROM THE

CHEMUNG AND WAVERLY GROUPS OF PENNSYLVANIA.

By Chas. E. Beecher.

The literature upon the subject of the palæozoic phyllopods is comparatively very meager and fragmentary. An occasional discovery of a few specimens, as in the present instance, has resulted in the publication of one or more new forms, but nothing has led to a compilation and review of the palæozoic forms of the whole order. The trilobita forming the bulk of palæozoic crustacea, and including such varied forms and numerous species, have received much attention from palæontologists, so that a nearly complete monograph of this order is now possible; while of the American ostracoda, merostomata, and phyllopoda, but little is yet known which would furnish materials for an exhaustive monograph of the fossil species.

In the present paper several new forms are presented and considerable structural detail is here first given for the genus Echinocaris, *Whitfield*, which it is hoped will add to our knowledge of the zoölogical relations of this and allied genera.

Bibliographical History.

1839.—The first palæozoic fossils of this order were found in England and published by Sir R. Murchison. Professor L. Agassiz considered them as fin-spines of fishes, and re-

ferred them to the genus ONCHUS. Only the separated portions of the trifid tail were then known, and this reference was not unnatural.

1850.—These fragments were ascribed to PTERYGOTUS and constituted as a sub-genus LEPTOCHELES by Professor McCoy. In the same publication he proposes the genus CERATIOCARIS, and describes two species.

1851.—The following year these species are again described by Prof. McCoy and properly classed with the Phyllopoda, which has since been the receptacle for all fossil forms of a similar nature.

1852.—In 1852, Professor Hall made the first announcement in America of the discovery of fossils similar to those described by Prof. Agassiz as *Onchus murchisoni*, and described the species *Onchus deweyi*, from the Niagara group of New York. (*Pal. N. Y. Vol. ii, p. 320.*)

1853.—M. J. Barrande pointed out the essential identity of the fossils described under the names of ONCHUS and LEPTOCHELES, with the telson and movable spines of CERATIOCARIS, and suggests that these names are superfluous.

Since this time a number of new genera have been established both in America and abroad, of which only those will here be noticed which lead directly to the species of the present paper.

1863.—In the 16th Report of the New York State Cabinet of Natural History, Professor Hall described four species of this order and referred three of them to the genus CERATIOCARIS. Two of these have since been recognized as having been described from different portions of individuals of the same species, and are now united under one species.

1876.—In 1876 the same author again illustrated these species and refered to one as *Ceratiocaris* (*Aristozoe*) *punctatus*, and suggested that the specimens designated as *Ceratiocaris armatus* were probably identical with it. (*Illustrations of Devonian Fossils, pl. 23.*)

1879.—Dr. A. S. Packard recognizes the importance of Nebalia and its fossil allies and their relations to the decapods, and proposes the order *Phyllocarida* for their reception. (*Zoölogy American Science Series, p. 703.*)

1880.—Professor R. P. Whitfield in 1880 (Am. Jour. Sci., vol. xix) described three allied species from the Devonian of Ohio and established the genus ECHINOCARIS, which is to include also, the species *Ceratiocaris* (*Aristozoe*) *punctatus*, Hall.

The present paper furnishes one new species belonging to the genus ECHINOCARIS and two related genera considered as new to science, under which are described four species.

Besides the crustaceans of the type of CERATIOCARIS, Professor J. M. Clarke has shown (Am. Jour. Sci., Vols. xxiii and xxv, 1882-3,) that the Devonian series furnishes another distinct but allied group belonging to the prototype DISCINOCARIS, *Woodward*. For the reception of these species he has erected the genera SPATHIOCARIS and DIPTEROCARIS.

1883.—In "*A Monograph of the North American Phillopod Crustacea*," Dr. A. S. Packard reviews the genera of the family ceratiocaridiæ and enumerates the described species.

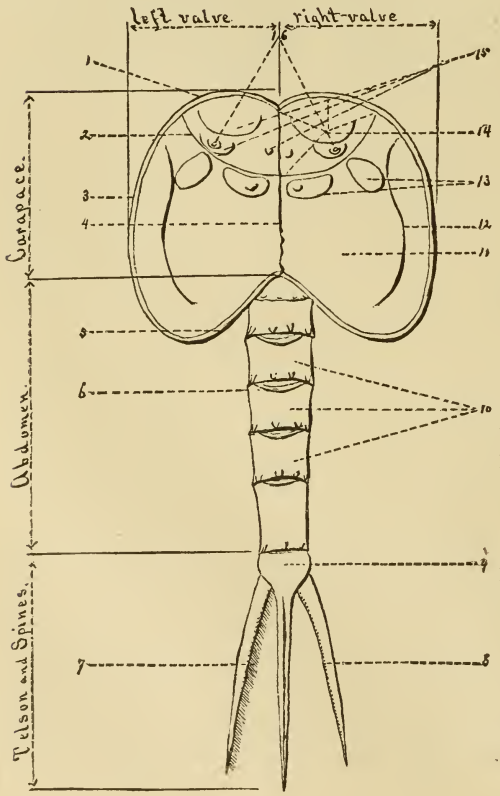
Terminology.

In the use of descriptive terms for the different members of these crustaceans, it has been deemed advisable to adhere to the established nomenclature, with perhaps a few slight introductions and variations. The terminology used is explained by the following diagram.

It has been suggested that the so-called "optic spots" of McCoy and other authors may only be frontal bosses, and not connected with vision. In recent forms such as *Apus* there are three eyes one of which is double [Baird], other genera show one (double) or two. In the species furnished with a rostrum the eyes were probably stalked. None of the genera of the present paper have yielded any evidence of a rostral plate, and it is doubtful if such an appendage will be discovered. The tubercle, as indicated above, is one of the most constant features of the carapace in all of the species and must have a special significance. In a number of specimens examined, by the writer, under the microscope a subcircular depression is observed at or

near the summit of this tubercle as in the ocelli of *Eurypterus*, etc. The fact that facets cannot be discerned is no criterion of their absence in the animal, for numerous trilobites and *Eurypterus* have as yet revealed no evidence of the compound character of their eyes, and on the other hand many species have large and distinct facets. It has also been noticed by Professor McCoy that this spot on the carapace is darker in the fossil than the general surface of the carapace, indicating the presence of pigment in the animal at this point. In the specimens of *Elymocaris siliqua*, *Tropidocaris bicarinata* and *T. interrupta* of the present paper this character is well marked.

figure 1.



Explanation of Fig. 1.

1. Anterior margin.
2. Furrow limiting the cephalic region.
3. Lower or ventral margin of valve.
4. Dorsal-line or hinge.
5. Posterior margin.
6. Articulating surface of somite.
7. Fimbria or setæ.
8. Crenulated inner margin of spine for the attachment of setæ.
9. Caudal plate.
10. Abdominal segments.
11. Thoracic portion of the valve extending to the furrow limiting the cephalic area.
12. Longitudinal ridge.
13. Nodes on the thoracic area.
14. Cephalic region.
15. Nodes and elevations.
16. Eye tubercles and optic spots.

Geological Range.

The following table gives the distribution of the described species of the genera ECHINOCARIS, ELYMOCARIS and TROPIDOCARIS. It is seen that the number of species reached its maximum in the Chemung group, which would naturally be expected from the almost total disappearance of the order *Trilobita* at the close of the deposition of the Hamilton group.

Besides the species of the list here given, I have seen two undescribed species of ECHINOCARIS, from the Chemung group, of New York; also a large form belonging to the genus ELYMOCARIS, from the Hamilton group of western N. Y.; and another species, probably belonging to the latter genus, from the same horizon in the central part of the State.

	Hamilton.	Genesee Sl.	Portage.	Chemung.	Waverly.
ECHINOCARIS, *Whitfield.*					
punctata, Hall,	×				
longicauda, Hall,		×			
sublevis, Whitfield,			×	×	
pustulosa, Whitfield,			×	×	
multinodosa, Whitfield,			×	×	
socialis, Beecher,				×	
ELYMOCARIS, *Beecher.*					
siliqua, Beecher,				×	
TROPIDOCARIS, *Beecher.*					
bicarinata, Beecher,				×	
interrupta, Beecher,				×	
alternata, Beecher,					×

Order PHYLLOCARIDA, (Packard, 1879.)

Family Ceratiocaridæ, Salter, 1860.

Genus ECHINOCARIS, Whitfield, 1880.

(*Am. Jour. Sci., Vol. XIX, p. 34, 1880.*)

Echinocaris punctata.

Plate I, Figs. 13-16.

Ceratiocaris? punctatus, Hall. Sixteenth Rep. N. Y. State Cab. Nat. Hist., p. 74. 1863

Ceratiocaris armatus, Hall. Sixteenth Rep. N. Y. State Cab. Nat. Hist., p. 72. 1863.

Ceratiocaris armatus, Hall. Illustrations of Devonian Fossils. Explanation of Pl. 23, Figs. 4, 5. 1876.

Ceratiocaris (*Aristozoe,*) *punctatus*, Hall. Illustrations of Devonian Fossils. Expl. Plate 23, Fig. 7. 1876.

Echinocaris punctatus, (Hall,) Whitfield. Am. Jour. Sci., 3d Ser., Vol. XIX, p. 7. 1880.

Capapace obliquely subovate in outline; widest just posterior to the middle, width about two-thirds of the greatest length, which is four-fifths of the free segments of the abdomen; compressed on the anterior half, becoming regularly convex over the posterior portion.

Dorsal line straight, about equal to the width of the valves, situated anteriorly, so that one-third the length of the valves projects beyond the posterior extremity of the hinge.

Margins distinctly marked by a thickening of the test, rounded in front, making a broad curve along the lower edge of the valve, more rapidly curving around the lower posterior portion, and extending in nearly a straight line to the extremity of the dorsal line.

The cephalic portion of the carapace is distinctly marked by a furrow beginning at a point a little anterior to the middle of the dorsal line, curving outward and extending to a point on the lower anterior margin of the valve. This area, therefore, occupies the upper anterior portion of each valve, and is of a broad triangular form with curved sides. It is ornamented by a large rounded elevation, narrow

towards the dorsum, broad and convex towards the lower portion, and occupying nearly one-half of the entire area. Near the center of the limiting furrow and just anterior, is a strong abruptly elevated node carrying the optic spot, which is usually marked by a slight depression on the summit of the node. There is also a small node in each valve adjacent to the dorsal line, near the posterior apex of the area.

The thoracic portion of the carapace is marked by two large tubercles, a long, sharp, doubly curved ridge, and a row of small nodes along the dorsal line. One of these tubercles is elliptical in outline, oblique, and situated near the middle of the anterior end, back of the optic node. The other elevation is elongate, with its longest diameter at right angles to the hinge, and marked by a small subcentral node. The ridge extends near the lower portion of the valve, concave to the margin along the anterior half of its extent, recurving and nearly following the contour of the lower posterior margin of the valve.

One specimen has been observed which preserves the mandibles *in situ*, and is represented in Fig. 16 of Plate I. The mandibles are broad and gibbous on the anterior portion becoming narrow below; furnished on their inner edge with a row of denticles; situated near the center of the carapace, and are nearly one-third the length of the valves.

Abdomen tapering towards the posterior end, composed of six exposed segments, having a total length of one-fourth greater than the length of the carapace. The segments increase in length towards the posterior segment, which has a length equal to two of the anterior segments, and is twice as long as wide; while the anterior somites have a greater width than length. The anterior dorsal margin of each is thickened and arched backwards; the posterior margin is furnished with from four to six strong spines, which project over the articulation of the succeeding segment. On the two anterior joints these spines are much shorter, appearing only as nodes. The ventral side is without spines, but is furnished with broad articulating faces. These characters indicate a great freedom of motion in the parts of the abdomen and account for the many positions in which this member is found.

Telson short and broad, flat and quadrangular on the ventral side; triangular and carinated on the dorsal side, and produced into a long, slender spine, having a length about equal to twice that of the posterior segment of the abdomen. To the ventral side of the caudal plate are articulated two movable spines, about equal in length to the spiniform extension of the telson. These spines are grooved along their lateral margins, and marked by a carina on their dorsal face.

Test thin, somewhat thickened on the margins and dorsal line of the carapace, and at the articulations of the abdominal segments; ornamented over the entire surface of the carapace, mandibles, abdomen, and tail with minute granules or pustules, which give a punctate appearance to the whole.

The specimen represented in Fig. 13 of Plate I has a length, exclusive of the tail spines, of 57 m m. The carapace measures 30 m m. in length, 20 m m. in breadth, and 18 m m. along the hinge-line. The segments of the abdomen, beginning with the anterior one, measure respectively 3.5, 3.7, 4, 4, 5, and 8.5 m m. in length,—showing that the posterior segment is more than twice the length of any of the first four segments. The three posterior ones, commencing with the distal segment, have diameters of 5.5, 7, and 8 m m. respectively. The left valve of this species figured in the 16th Rept. N. Y. State Cab. Nat. Hist. has a greatest length of 55 m m., with a breadth of 37 m m. The three abdominal segments figured in the same publication also belonged to a much larger individual than any noted in the present description.

This species differs from *E. sublevis*, Whitfield, (Am. Jour. Sci., Vol. XIX, p. 36,) in the more numerous nodes and tubercles of the carapace, the curvature and direction of the ridge along the thoracic portion, and in its more elongated abdominal segments. The same characters serve to distinguish it from *E. pustulosa*, Whitfield, (loc. cit.,) with the addition of a marked difference in the surface ornamentation, which in that species is distinctly pustulose. It is readily distinguished from *E. socialis*, in its larger

size, less conspicuous and differently located nodes, and in the more simple character of the ornamentation.

This well-marked species occurs in the shales of the Hamilton group at several localities in the central portion of the State of New York. It is here introduced for the sake of comparison, and for a better elucidation of the characters of the following species. I am indebted to Professor James Hall, for the permission to examine and figure specimens of this species, belonging to the New York State Museum, at Albany. These collections furnish conclusive evidence of the identity of the abdomen and telson, referred to *Ceratiocaris armatus*, with the carapace described as *Ceratiocaris? punctatus*.

The specimen Fig. 16, Plate I, is the only one yet observed in this genus showing the mandibles and their position. In 1865 Professor Henry Woodward, of the British Museum, described and figured a specimen of *Ceratiocaris papilio* which preserved the mandibles and showed the position which they occupy in the carapace. These two examples add materially to our knowledge of the characters of this group, and with the nearly entire specimens described in this and in the succeeding species, furnish us with material for a comparison with their recent ally—*Nebalia*.

Some of the specimens are covered with numerous examples of a small species of *Crania*, which from the perfect preservation of the *Echinocaris* were probably attached during the life of the crustacean. The shales carrying these remains are highly charged with other fossils, among which are fragments of fishes, *Beyrichia*, *Leperditia*, *Phacops*, *Homalonotus*, *Orthoceras*, *Nautilus*, *Loxonema*, *Pleurotomaria*, *Bellerophon*, *Platyostoma*, numerous species and genera of lamellibranchiata, with a few species of brachiopods and bryozoans.

Associated with numerous specimens of *E. punctata* are frequently found mandibles or jaws of the form represented in Figs. 9–11 of Plate II. These are evidently of crustacean origin and although somewhat similar in form to the mandibles undoubtedly belonging to *E. punctata*, they probably

belong to a species otherwise unknown. In general form they are triangular with a broad flat manubrium for articulation or the attachment of muscles. Inner or masticating side arched laterally, concave to the dorsal side of the carapace. Crown lunate, broadest anterior to the middle, and furnished with a row of usually six, more or less, bicuspid denticles. The denticles become more prominent and acute towards the posterior extremity of the crown, where they are also somewhat oblique, while anteriorly they are broad and obtuse. The test forming the crust of the mandible reaches a thickness of more than one mm. over the denticles, but becomes very thin over the expansions of the sides and on the manubrium. For this reason very few of the specimens preserve more than merely the row of denticles.

M. J. Barrande has figured and described several specimens of a similar nature and has referred them to the genus *Ceratiocaris* from their association with species of this genus in the Silurian of Bohemia. It is therefore probable that these portions of the animal do not furnish sufficient generic character to be of importance.

Formation and localities.—In the shales of the Hamilton group; at Delphi, Pratt's Falls, and the shore of Cayuga lake, New York.

Echinocaris socialis, *n. sp.*

Plate I, Figs. 1–12.

Carapace convex, obliquely ovate in outline, widest posterior to the middle, length about one-third greater than the width. Dorsal line straight, oblique, having a length of more than one-half the longest diameter of the valves. Margins thickened, carinated, curving outwards over the anterior end of the valves at nearly right angles to the direction of the hinge, continuing in a broad curve to the lower posterior end, where the margin is abruptly rounded, thence extending in nearly a straight line to the hinge.

Cephalic region triangular in each valve, distinctly limited by a furrow extending from the center of the dorsum, curving outwards and downward to the anterior margin,

and occupying about a fourth of each valve. This area is ornamented in each valve with a prominent rounded tubercle at its posterior dorsal apex; and a large rounded elevation occupying the whole anterior end of the valve, making in all four prominent elevations on the cephalic area. The optic node is situated on the lower side of the largest tubercle and adjacent to the limiting furrow.

The thoracic portion of the valve is ornamented with an elongate tubercle near the middle of the anterior portion, produced into a nodose ridge following the contour of the lower margin and dying out before reaching the posterior end. A similar tubercle, but situated transversely, is found in the upper dorsal portion, and is continued in a nodose ridge adjacent to the dorsal line, and along the posterior margin of the valve. In the center of the area partially enclosed by these two ridges is a less prominent longitudinal row of minute nodes forming a third carina.

The valves are also ornamented with minute irregular tubercles on the summits of all the elevated portions of the valves, a single row appearing along the three ridges and around the extreme margin of the posterior portion.

Abdomen composed of six naked segments, which become more elongate towards the telson. Somites cylindrical, marked by a thickened rim on the anterior end; ornamented with four or more spinose nodes across the middle of the dorsal side, and by a row of smaller retral spines or nodes around the posterior dorsal margin.

Caudal plate short, triangular, produced behind into a slender, acute, carinate spine, having a length equal to one-half the abdomen; also two lateral movable spines, extending as far as the prolongation of the telson. Test thin.

The largest carapace observed has a length of 18 mm., and a width of 10 mm. A single cercopod belonging to a large individual has a length of 25 mm. A small entire example has a total length of 16 mm., of which 6 mm. pertain to the carapace, 6 mm. to the abdomen, and 4 mm. to the telson and spine.

This species is more highly ornamented than any yet described, and is the only one of the genus observed in the

rocks of the Chemung group in Pennsylvania. It somewhat resembles *E. pustulosa*, Whitf., but has more nodes and ridges ornamenting the carapace, and is without the entirely pustulose surface of that species. *E. sublevis*, Whitf., has but a single row of spines on each abdominal somite, and the lateral ones are of considerable length.

The series represented in Figs. 1–4 of Plate I, shows the different positions of the abdomen in relation to the carapace, which have been observed, and illustrates the great flexibility of this portion of the animal. Fig. 1 represents the abdomen extending in the direction of the longer axis of the carapace, and probably shows the normal position of the parts. In Fig. 2 the abdomen is elevated above the dorsum. Fig. 3 shows the valves open, with the abdomen closely curved around the posterior end of the left valve. The specimen represented in Fig. 4 has the position of the abdomen the reverse of Fig. 1, extending obliquely from between the anterior ends of the valves. Specimens in the first and second of these positions are represented on the piece of rock shown in Fig. 12, which also illustrates the abundance of specimens in some portions of the shales. The single fragment in question contains the remains of fifteen separate individuals, nine of which are shown on the side represented in the figure.

The specimens of *Elymocaris siliqua*, and *Tropidocaris bicarinata*, which have been thus far found, are associated with this species.

Besides the remains of the crustaceans here described, there are also several fragments in the collections from these shales which belong to other forms of crustacea, but are too obscure to furnish satisfactory information as to their nature and characters. In addition to the crustaceans are numerous species of lamellibranchiata in the same occurrence; also one or two species of brachiopoda, an Orthoceras and the teeth and scales of fish.

The data furnished by the specimens of *E. punctata* and *E. socialis* fix the number of naked abdominal segments in the genus at six.

Formation and locality.—In the shales at the base of the

Chemung group as exposed at Warren, Pa.; belonging to the upper strata of the series when considered in relation to the entire thickness of the group in New York and Pennsylvania.

ELYMOCARIS, NOV. GEN.

[Ἕλυμος, *siliqua; χαρις, caris.*]

Carapace bivalve, dorsal line nearly equaling the length of the valves. Valves elongate, longitudinally sub-quadrangular or sledge-shaped, extending posteriorly slightly beyond the hinge-line. Margins thickened, regularly curving from the anterior extremity of the hinge, making a broad sweep along the lower margin, rapidly curving around the lower posterior end, and extending to the hinge.

Cephalic region marked by a distinct optic node near the anterior end of the valve, behind which are two low, broad elevations. Thoracic portion regularly convex. Rostrum unknown.

Abdomen composed of two naked segments. Telson consisting of a short broad spine, with two strong lateral spines, which are crenulated along their inner margins for the attachment of fimbria.

Test thin and without special ornamentation in the typical species of the genus, which shows only vascular striæ along the margins of the valves, and over the segments of the abdomen.

This genus differs conspicuously from ECHINOCARIS in the form and ornamentation of the valves, and in the number and character of the segments of the abdomen. In the outline of the valves it is very similar to TROPIDOCARIS, and is distinguished by the absence of the strong longitudinal ridges presented by the species of that genus.

ELYMOCARIS SILIQUA, *n. sp.*

Plate II, Figs. 1, 2.

CARAPACE regularly convex, pod-shaped, dorsal line straight, somewhat shorter than the greatest length of the valves. Valves elongate, longitudinally sub-quadrangular or rhomboidal in outline; length equal to more than twice the greatest width. Margins thickened, regularly curving

outwards and backwards over the anterior end, extending in a broad curve along the lower margin, rapidly recurving around the lower posterior portion, and continuing concave and obliquely forward to the extremity of the hinge, making the hinge-line appear as slightly produced.

The cephalic area occupies the anterior third of the valves, and is marked at its base by two broad flattened oval elevations, of which the lower one is somewhat the larger. Optic node prominent, situated above the middle of the area.

Thoracic region convex over the anterior portion, becoming flattened on the posterior half, without nodes or ridges.

Abdomen having a length of less than half that of the valves, composed of two naked cylindrical segments. The posterior segment is one-third longer than wide, somewhat larger at its anterior end. Anterior segment partially concealed by the carapace in the specimen described. The margins are slightly thickened.

Telson consisting of a stout triangular spine flattened on the ventral side, rounded above, and marked by a longitudinal carina along the middle. Lateral spines longer than the extension of the telson, flattened; margins thickened; marked by two sharp longitudinal ridges on the dorsal face. The inner edges of the movable spines are crenulate for the attachment of setæ.

Test thin, not exceeding $\frac{1}{10}$ mm. in thickness, minutely wrinkled over the surface of the valves, except on their margins and the abdominal segments which are ornamented with fine curving striæ or vascular markings.

An entire left valve has a greatest length of 23 mm., width 10 mm., and hinge-line 20 mm. In a specimen preserving a portion of the valves with the abdomen and its appendages, the valves have a width of 11 mm., and the length from the distal extremity of the telson to the insertion of the abdomen with the carapace measures 20 mm.

The three specimens of this species observed, present such marked differences from any described form, that it seems advisable to arrange them under a new generic designation. The presence of crenulations along the inner mar-

gins of the lateral spines of the tail show that it was furnished with fimbria similar to those illustrated for *Dithyrocaris neptuni*, Hall, in *Illustrations of Devonian Fossils*, explanation of Plates XXII, XXIII. The other characters are very different, however, from that genus, in the absence of an anterior sinus for the reception of the rostral plate, the want of a strong ridge on the valves, the posterior spiniform projection of the lower posterior end of the valve, and in the number of abdominal segments. The posterior spines of *Dithyrocaris* are not a mere prolongation of the upper surface of the valves but are produced by the extension of the infolded thickened rim of the lower side of the valves.

Formation and locality. In the lower arenaceous and micaceous shales of the Chemung group, as exposed at Warren, Pennsylvania.

TROPIDOCARIS, NOV. GEN.

[τροπις, *carina;* καρις, *caris.*]

Carapace bivalve, semi-ovate or semi-elliptical in outline, obliquely truncated behind. Dorsal line straight, nearly equal to the length of the valves. Valves about twice as long as wide, ornamented with one or more strong longitudinal ridges. Cephalic region indicated by broad, rounded elevations on the anterior ends of the valves, or by a difference in convexity from the remainder of the carapace. Optic node well-marked, and in the species known, is situated on one of the smaller secondary ridges. Rostrum not observed.

Two segments of the abdomen are known, which are cylindrical and without nodes or spines. The extent of the telson and appendages has not been observed. The species described show a range of from 15 to 40 mm. in the length of the carapace.

This genus differs in the form and ornamentation of the carapace from CERATIOCARIS. Its relations with ELYMOCARIS are quite apparent in the outline of the valves and probably equal number of segments in the abdomen. The successive appearance of three distinct species having a similarity of ornamentations from widely separated horizons indicates a permanence of character which is of generic importance.

The three species in question also illustrate in a very satisfactory manner the successive appearance of higher types in the same genus. Beginning with *T. bicarinata*, at the base of the Chemung group as exposed at Warren, Pennsylvania, we have a species exhibiting but two strong longitudinal ridges on each valve. Ascending in the series of rocks at the same locality, and near the uppermost beds of the Chemung group, is found *T. interrupta*, the valves of which are each ornamented with from four to five strong carinæ and several shorter intermediate ridges. Three hundred and fifty feet higher in the series, in sandstones of the Waverly group, occur the examples of *T. alternata*, which show a still farther increase in the number of longitudinal ridges on the carapace, and with a still greater variation from their alternating size and ornamentation.

The species of this genus are conspicuously different from ECHINOCARIS in their more elongate valves, the strong ridges of the carapace, and in the absence of spines or nodes on the abdomen, which is also probably composed of fewer segments.

TROPIDOCARIS BICARINATA, *n. sp.*

Plate II, Figs. 3-5.

CARAPACE elongate, semi-elliptical, obliquely truncated behind. Dorsal line extending nearly the entire length of the valves. Valves quite convex transversely; length from two and one-half to three times the width. In mature individuals, the greatest width is across the center of the length of the valves. Anterior end pointed. Margins regularly curving from the anterior extremity of the hinge, to the lower posterior end, thence rapidly curving inwards, and extending concave and slightly oblique, to the extremity of the hinge-line. The margins are strengthened by a thickening of the test, forming a rounded striated ridge, which extends the entire circumference of the valves.

Cephalic region occupying about one-fourth the area of the carapace, indicated by a slight change in the convexity of the valves and by several low, obscure elevations. The valves are each ornamented with two strong, longitudinal

ridges extending nearly their entire length. The ridge nearer the dorsal line commences near the apex of the valve, following adjacent and parallel to the dorsal line to the base of the cephalic area, and then diverging, extends almost to the posterior end of the valve, at about one-third the width of the valve from the hinge. The lower ridge also starts from the apex of the valve and is slightly curved, convex to the lower margin. This latter ridge is much more elevated and stronger, than the upper one, and is situated midway between it and the lower margin of the valve. The optic node is at the posterior extremity of a small carina, between the two prominent ridges, extending to the base of the cephalic area.

Surface of the carapace marked by fine sharp irregular striæ, which are more conspicuous over the cephalic area and margins of the valves than on the thoracic portion.

Abdomen cylindrical, gradually tapering to the posterior end. But two segments are known, of which the anterior has a length equal to its transverse diameter; and in the posterior segment the length is twice the diameter. Lower edges thickened, anterior margins furnished with a rim for articulation with the adjacent segment. Surface marked by curved striæ, which meet along the dorsal side.

Telson short and strong, produced into a spine of which the entire length is not known. Lateral spines not observed.

Test comparatively strong on the margins of the valves, the ridges of the carapace, and the ends of the abdominal segments.

The largest valves observed have a length of 39 mm., and a width of 14 mm. A small valve has a length of 15 mm., with a breadth of about 6 mm. Two segments of an abdomen measure respectively 3.5 and 6 mm. in length.

This species is distinguished from *T. interrupta* and *T. alternata* by having only two prominent ridges on each valve. The apices of the valves in *T. interrupta* are mucronate, and in *T. alternata* every alternate ridge is stronger and crenulated along its summit, none of which characters appear in the present species.

The description of the abdomen is taken from a specimen

which, although not found attached to a carapace, is referred to this species on account of the similarity in surface ornamentation and from its association with specimens of the carapace of this species.

Formation and locality. In shales at the base of the Chemung group, as exposed at Warren, Pa.

TROPIDOCARIS INTERRUPTA, *n. sp.*

Plate II, Fig. 6.

CARAPACE semi-oval in outline, obliquely truncated behind, slightly mucronate in front. Dorsal line straight, somewhat shorter than the greatest length of the valves. Valves regularly convex, widest in the middle, length more than twice the greatest breadth. Lower and anterior margins regularly curving to the lower posterior end of the valve, which is abruptly rounded, and from whence the margin is concave to the extremity of the hinge.

Cephalic area marked by a slightly greater convexity than the remainder of the valve, and showing two or three obscure rounded elevations. Optic spots indicated by a swelling or tubercle on one of the short ridges extending from the apex of the valves. Valves ornamented with three strong ridges which extend the entire length, and by three or four similar ridges extending more than one half the length of the valves. Also on the cephalic region there are from four to five smaller carinæ which extend less than half the length of the valve. Abdomen, telson and appendages unknown.

Test thin, slightly thickened around the margins of the valves.

The right valve described has a greatest length of 23 mm., a width across the middle of about 10 mm., and the dorsal line measures 21 mm.

The carapace of this species somewhat resembles that of *T. alternata*, but in that species the ridges regularly alternate in size and the stronger ones are ornamented with a double series of minute pits along their summits. The greater number of carinæ on the valves readily distinguishes it from *T. bicarinata.*

In its geological position this species occurs about two hundred and fifty feet higher in the Chemung series than the beds carrying *T. bicarinata*, and about three hundred and fifty feet below the beds in the Waverly group, in which are found *T. alternata*. These beds of the Chemung and Waverly groups at Warren are conformable and in uninterrupted succession.

Formation and locality.—In soft shales belonging to the Chemung group as exposed at an elevation of three hundred feet above the Alleghany river at Warren, Pa.

Tropidocaris alternata, *n. sp.*

Plate II, Figs. 7, 8.

This species is represented in the present collections by two imperfect left valves, which do not admit of an extended description. The carapace is elongate, at least twice as long as wide, and quite convex. The cephalic region is marked by two broad, rounded elevations on the lower anterior end of the valve, and by a prominent node produced by a swelling and elevation of one of the secondary ridges, which carries the optic spot.

Valves furnished with seven or more very prominent, longitudinal ridges, alternating in size, and continuing the whole length of the thoracic portion of the carapace. On the line separating the cephalic area these ridges are more or less interrupted, but again appear and continue apparently to the apex of the valve. The stronger ridges are ornamented along their summits with a double row of minute pits, while the intermediate ones are simple and sharp. Abdomen and telson unknown.

Distinguished from *T. interrupta* by the alternating character of the longitudinal ridges of the carapace. One of the specimens figured shows the imprint of the plates of an echinoderm which was bedded with it.

Formation and locality.—In the sandstones of the Waverly group at Warren, Pennsylvania, associated with numerous species of brachiopoda, lamellibranchiata, gasteropoda, and other fossils.

EXPLANATION OF PLATES.

PLATE I.

ECHINOCARIS SOCIALIS, *Beecher*.

Page 10.

Fig. 1. A small example with the abdomen directed posteriorly, in a line with the longer axis of the carapace.

" 2. A similar specimen, in which the abdomen is elevated above the dorsum.

" 3. An individual with the valves opened and the abdomen closely curving around the posterior margin of the left valve.

" 4. Similar to the preceding, but with the abdomen protruded in front of the valves.

" 5. An example preserving the carapace and four naked segments, showing the form and ornamentation of these parts of the test.

" 6. A carapace with the valves opened, showing the distinct furrow limiting the cephalic and thoracic portions, the optic spots indicated by dotted lines, and the nodose ridges and elevations ornamenting the valves.

" 7. A smaller carapace, presenting immature characters, belonging to a young example.

" 8. Fragment preserving three abdominal segments, the telson and lateral spines showing the form and ornamentation.

" 9. Two segments of another fragment, enlarged to two diameters, to show the ornamentation and nature of the articulating surfaces.

" 10. A small telson with the attached lateral spines, showing their form and longitudinal carinæ.

" 11. A piece of shale with an impression of the caudal plate, and with one of the lateral spines, belonging to a large individual.

Fig. 12. A fragment of shale preserving the remains of fifteen young individuals, nine of which are to be seen on the side represented in the figure.
Chemung group; Warren, Pa.

ECHINOCARIS PUNCTATA, *Hall.*

Page 6.

Fig. 13 A nearly entire individual showing the form and relation of the parts, and the number of naked abdominal segments.

" 14. An enrolled specimen, with the valves partially opened and the abdomen extended along the ventrum. The specimen shows in a very satisfactory manner the optic spots, the number and distribution of the nodes, and the limits of the cephalic region.

" 15. *id.* Lateral view, showing the position of the abdomen in this example. The specimen is flattened, and does not represent the normal convexity of the valves.

" 16. The ventral side of a specimen preserving the mandibles *in situ.*
Hamilton group; New York.

PLATE II.

ELYMOCARIS SILIQUA, *Beecher.*

Page 13.

Fig. 1. A specimen wanting the anterior portion of the carapace, but preserving the abdomen and telson, with its appendages.

" 2. The carapace with the valves separated, showing their form with the rounded elevations and optic nodes on the cephalic portion.
Chemung group; Warren, Pa.

TROPIDOCARIS BICARINATA, *Beecher*.

Page 16.

Fig. 3. A carapace with the valve opened and the test somewhat broken, showing the eye-tubercles and a pair of longitudinal ridges on each valve.

" 4. The right valve of a smaller individual.

" 5. Two segments of the abdomen with a portion of the telson attached, showing the form and ornamentation of the somites.

Chemung group; Warren, Pa.

TROPIDOCARIS INTERRUPTA, *Beecher*.

Page 18.

Fig. 6. A right valve of this species showing the form and ornamentation.

Chemung group; Warren, Pa.

TROPIDOCARIS ALTERNATA, *Beecher*.

Page 19.

Fig. 7. An imperfect left valve, preserving the longitudinal ridges, and showing the tubercles and optic node on the cephalic portion.

" 8. A fragment of a large left valve, bearing the impress of the plates of an echinoderm.

Waverly group; Warren, Pa.

MANDIBLES.

Page 9.

Fig. 9. A specimen preserving the manubrium, and showing the number and character of the denticles.

" 10. The inner edge of a smaller example.

" 11. The crown of a large specimen with the denticles well-preserved and showing its arched and lunate form.

Hamilton group; New York.

NOTE

ON THE

EURYPTERIDÆ

OF THE

DEVONIAN AND CARBONIFEROUS FORMATIONS

OF PENNSYLVANIA.

By James Hall.

In April, 1877, Mr. Charles E. Hall, of the staff of the Second Geological Survey of Pennsylvania, communicated to the American Philosophical Society the description of a species of Eurypterus, (*E. Pennsylvanicus*,)from the Lower Carboniferous rocks of Venango county, and another one from the coal measures of Cannelton, Pennsylvania, under the name of *Eurypterus* (*Dolichopterus*) *Mansfieldi*, from the collection of Hon. I. F. Mansfield. The length of the latter specimen described, without the terminal joint, was two and three-fourths inches.

In April, 1881, Mr. Mansfield communicated to the Philosophical Society "a drawing of a fine fossil Eurypterus, found by him in the shale immediately beneath the Darlington cannel coal bed, lower productive coal measures." This specimen has an entire length of nine inches, of which the telson constitutes about three inches. At a later period Mr. Mansfield placed his collection of these fossils in the hands of Professor Lesley to be described and illustrated in the publications of the Geological Survey. Mr. C. E. Hall

having completed his work, and being no longer connected with the Survey, the specimens have been placed in the hands of the writer for study and illustration.

The specimens of shale containing these remains amount to more than twenty in number, some of them containing only fragments of the fossil crustaceans, and nearly all of them containing coal plants. Two of the fossils are very large and fine specimens, being nearly complete. Several other smaller specimens are essentially complete in their parts and well-preserved, though from extreme compression in the black shale it is difficult to see the details of the organs and the surface sculpture. Several of the fragmentary portions and separated organs of the fossils are very interesting and instructive.

A critical examination shows what are apparently two very distinct forms, which can be clearly characterized, besides other portions of much larger forms, which are at present unknown in their entire condition. All the better preserved specimens, as well as all the separated members or fragmentary portions having any important significance, have been drawn in a very complete and artistic manner by Mr. George B. Simpson, and are reproduced in heliotype.

Although several species of this family have been described from the carboniferous rocks of Europe, we have heretofore known but a single species from rocks of the same age in America. In the *American Journal of Science*, Vol. 46, p. 21, 1868, Messrs. Meek and Worthen published the description of *Eurypterus* (*Anthraconectes*) *Mazonensis* from the coal measures of Grundy county, Illinois, and the same is illustrated and farther described in the third volume of the reports of the Geological Survey of Illinois, page 544, 1868. The accompanying illustration, with the explanations, is copied from the volume cited:

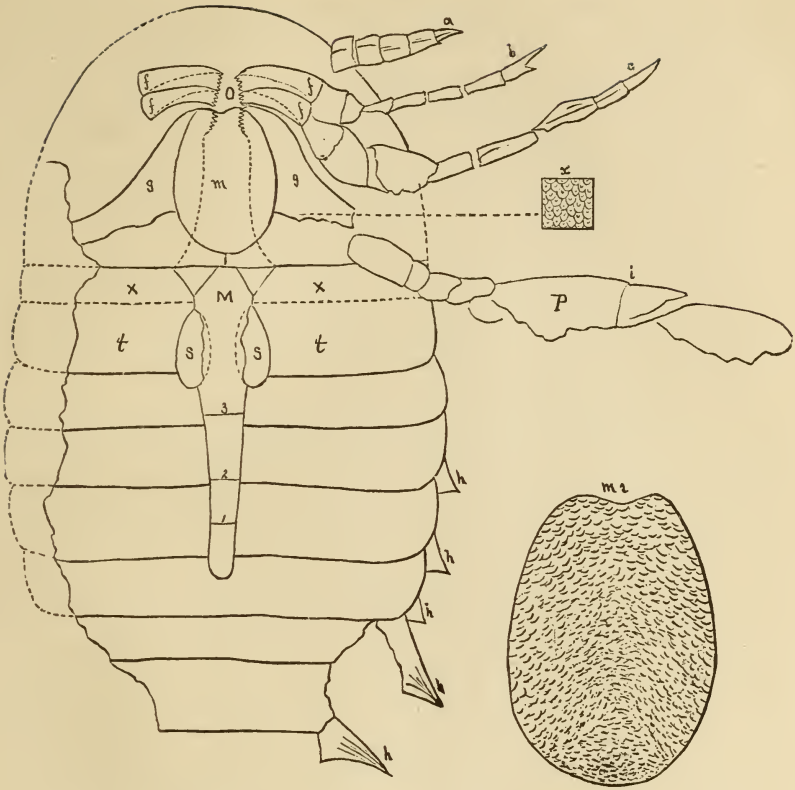


Fig. 2.—EURYPTERUS (ANTHRACONECTES) MAZONENSIS—nat. size.

"*a*, *b*, *c*. Crushed and broken legs as they appear in the specimen, the di-
"visions not being all natural articulations.
"*h*, *h*, *h*, *h*, *h*. Impressions of angular ends of the dorsal half of body seg-
"ments.
"*m*. Hypostoma in place; m^2, the same enlarged to show the scale-like
"sculpturing.
"*P*. One of the paddles or swimming feet in a broken condition. Its divi-
"sion at *i* seems to be a natural articulation.
"*g*, *g*. Basal joints of same; *x*, enlarged surface-sculpturing of the latter.
"*M*. Mesial appendage of the operculum; *1*, *2*, *3*, its apparent articula-
"tions; *s*, *s*, two little accessory pieces; *x*, *x*, *t*, *t*, lateral alae of operculum.
"*o*. Position of mouth."

After describing the fossil and its parts the authors remark: "From some of the characters mentioned above it "will be seen that this fossil differs from the typical forms "of Eurypterus, particularly in the great length and sim-

"ple extremity of the mesial appendage of its operculum, "as well as in the possession of two little spatulate supple- "mentary pieces (*ss*). Hence we very strongly suspect "that other characters will be found, when better speci- "mens can be studied, showing it to belong to a distinct "sub-genus, if not indeed to an entirely distinct genus from "Eurypterus proper, in which case we have proposed for it "the name Anthraconectes."

Whether these differences noted are of sufficient importance to constitute generic or subgeneric distinction may perhaps admit of different opinion, depending upon the interpretation of the relative value of variations of certain parts of the organism.

A specimen from Mazon creek for many years (from 1860) in my own collection and now in the American Museum of Natural History in New York City, appears to be not only identical with this one, but a counterpart or impression of the specimen described by Messrs. Meek and Worthen (see Fig. 3). It is less complete in its appendages, but the form and proportions of the body and the measurement of the parts correspond in all particulars. The mesial appendage of the thoracic plate extends to the sixth segment, as shown by a median ridge extending to that point, but it cannot be determined whether the posterior extremity is simple or bifurcate. The lines indicating the anterior attachment of this plate are visible but obscure. The existence of the two lateral accessory plates shown in the preceding figure cannot be determined, and the apparent jointing of the median appendage of the thoracic plate is produced by the impress of the articulating surfaces of the body segments.

The accompanying figure will illustrate this specimen and is given for the purpose of comparison with the figures upon Plates IV, V and VI of this paper. So far as evidence from this specimen goes there are no means of separating it from Eurypterus proper, the post lateral processes of the articulations, which become spiniform below, being only a greater development of corresponding parts in forms of that genus.

In comparison with the specimens from the coal measures of Pennsylvania, the Illinois species is more robust, the

joints of the palpi and the entire palpi are longer, and the body is conspicuously shorter and broader.

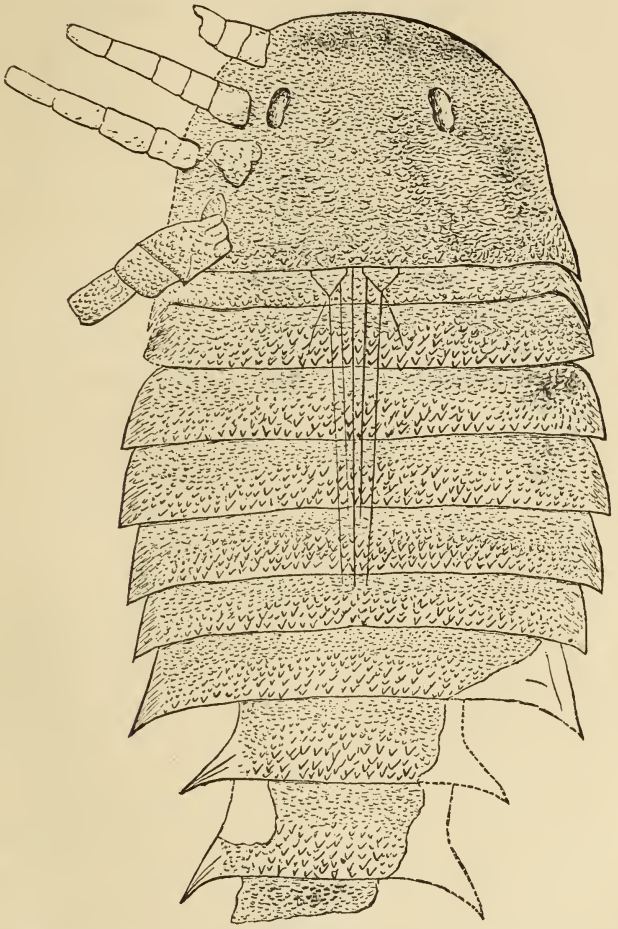


Fig. 3.—EURYPTERUS (ANTHRACONECTES) MAZONENSIS, Meek and Worthen. A figure of the specimen which forms the matrix or reverse of Fig. 2.

The Cannelton specimens possess the characters of typical Eurypterus in all the more important parts. The carapace is in all respects that of Eurypterus ; the form and position of the eyes are the same. The body and telson are entirely identical with species of that genus. The median appendage of the thoracic plate is narrow, elongate, and bifurcate at the posterior extremity as in Eurypterus. The

metastoma or post-oral plate found both in the same association and attached is of similar form, with a proportionally greater width than in the ordinary forms of Eurypterus, and approaches more nearly to the form of the same appendage in Pterygotus. The single dactylus at the extremity of the palpi corresponds with known forms of Eurypterus described by Mr. Henry Woodward, and may also be compared with the corresponding part of Pterygotus. The spiniform extensions at the post-lateral extremities of the segments of the body and thorax are but a more extreme development of a feature which is common to all true Eurypterides, and can scarcely be considered of generic importance.

In the elongated joints of the swimming foot and their serrated margins the Pennsylvania forms resemble Dolichopterus, and may be referred to that sub-genus with as much propriety as to any other sub-generic form. In this respect the *Eurypterus* (*Anthraconectes*) *Mazonensis* is still more similar to Dolichopterus in its simple elongate median appendage of the thoracic plate. The two small accessory lateral plates of the median appendage of that species have not been detected in *E. Mansfieldi*, and their presence in the former species may perhaps, if verified, be considered as of sufficient importance for the separation of that form as a sub-genus. Finally, the forms are not as far removed from the typical species of Eurypterus, in any of their characters, as are several of those which Mr. Woodward has described from the Upper Ludlow rocks of England, and which he does not hesitate to place under the genus Eurypterus.

The Pennsylvania forms are quite unlike the European carboniferous species in their general aspect and proportions, as well as in the details of parts of their organization, and in these respects more nearly resemble the typical forms or the genus.

In addition to the two very well-marked forms described, there are, in the collections examined, several fragments of other crustaceans of this family which cannot be satisfactorily referred to genus and species. Two of these are figured on Plate IV, Figs. 9, 10. The specimen, Fig. 9, is an ectognath belonging to a large form of which we have also

other evidence in a fragment of a large somite which is too imperfect to be usefully illustrated. The specimen, Fig. 10, presents the inner surface of a fragment of some large crustacean, which is broken and incomplete along the upper margin, as shown in the figure. This may, perhaps, have been a portion of a large ectognath of some species of this family.

In addition to the above mentioned forms, Mr. C. E. Beecher has placed in my hands for description a well-marked species of Eurypterus from a sandstone of the Chemung group at Warren, Pennsylvania. This species is the first one noted from this horizon and is of considerable interest.

TABULAR VIEW OF THE GEOLOGICAL DISTRIBUTION OF THE FAMILY EURYPTERIDÆ IN THE UNITED STATES.

	Waterlime.	Lower Helderberg.	Upper Helderberg.	Hamilton.	Portage.	Chemung.	Catskill.	Waverly.	Carboniferous.
Eurypterus, DeKay, 1825,	. .	.	. .	. .	. .	. .	. .	. .	. .
E. Beecheri, Hall,	. .	. .	.	. .	. .	+	. .	. .	. .
E. Dekayi, Hall,	+	. .	. .	. .	. .	.	. .	. .	. .
E. Eriensis, Whitfield,	.	+	. .	. .	. .	. .	. .	. .	. .
E. lacustris, Harlan,	+	. .	. .	. .	. .	. .	. .	. .	. .
E. " *var, robustus*, Hall,	+	. .	. .	. .	. .	. .	. .	. .	. .
E. Mansfieldi, C. E. Hall,	. .	. .	. .	. .	. .	. .	. .	. .	+
E. Mazonensis, Meek and Worthen,	. .	. .	. .	. .	. .	. .	. .	. .	+
E. micropthalmus, Hall,	. .	+	. .	. .	. .	. .	. .	. .	. .
E. pachychierus, Hall,	+	. .	. .	. .	. .	. .		. .	. .
E. Pennsylvanicus, C. E. Hall,	. .	. .	. .	. .	. .	. .	. .	. .	+
E. potens, Hall,	. .	. .	. .	. .	. .	. .	. .	. .	+
E. pulicaris, Salter,	. .	. .	. .	. .	. .	. .	. .	. .	+
E. pustulosus, Hall,	+		. .	. .	. .	. .	. .	. .	.
E. remipes, DeKay,	+	. .	. .	. .	. .	. .	. .	. .	.
E. stylus, Hall,	. .	. .	. .	. .	. .	. .	. .	. .	+
E. tetragonopthalmus, Fischer,	+	. .	. .	. .	. .	. .	. .	. .	. .
	16	7	2			1			6
Dolichopterus, Hall, 1859,									
D. macrocheirus, Hall,	+	. .	. .	. .	. .	. .	. .	. .	. .
Pterygotus, Agassiz, 1839,									
P. Buffaloensis, Pohlman,	+	. .	. .	. .	. .	. .	. .	. .	. .
P. Cobbi, Hall,	+	. .	. .	. .	. .	. .	. .	. .	. .
P. Cummingsi, Grote and Pitt,	+	. .	. .	. .	. .	. .	. .	. .	. .
P. macropthalmus, Hall,	+	. .	.	. .	. .	. .	. .	. .	. .
P. Osborni, Hall,	+	. .	. .	. .	. .	. .	. .	. .	. .
Stylonurus, Page. 1856,									
S. Excelsior, Hall,	. .	. .	. .	. .	. .	. .	+	. .	. .

MEROSTOMATA.

EURYPTERUS, Dekay, 1825.

EURYPTERUS BEECHERI, *n. sp.*

Plate III, Fig. 1.

Carapace unknown. Body elongate, very convex along the dorsum, composed of twelve free segments which gradually increase in breadth from the head backwards to the fifth somite, from whence they rapidly decrease in width and increase in length, until the eleventh segment has a length equal to half its width, while in the fifth segment the breadth is four times its length. Lateral margins of the segments flattened, and slightly extended backwards on the post-lateral angles, forming a mucronate projection. The posterior tergal margin of each somite is ornamented with several triangular scales or nodes, pointing towards the telson. The number of these nodes on each segment decreases from the anterior segment, which has eight or more, to the tenth somite which is furnished with six. The number on the two posterior segments is not known, on account of their imperfect preservation in the specimen described.

Two joints of one of the great swimming feet are preserved, which are remarkable for their great length and for three or more strong longitudinal carinæ ornamenting them. The distal joint of the two has a length of more than three times its breadth, while the other has a length of nearly five times its breadth. These joints are probably the third and fourth from the attachment of the limb and correspond to the basos and ischium of a typical decapod. Telson and other appendages unknown.

The twelve free segments of the body have a total length of 96 mm., and the width of the fifth segment is 41 mm. The body measures 39 mm. across at the first segment and 25 mm. at the tenth. The longer joint of the natatory appendage has a length of 30 mm.

The specimen from which the present description is taken was found in a bed of fine grained sandstone occurring in the Chemung group at Warren. Although lacking many of

the important members and appendages of the animal, the body is sufficiently well-preserved to distinguish the species, which is also characterized by the ornamentation of the joints of the swimming limbs. The occurrence of crustaceans of this character, in these rocks, is so rare that every specimen is of importance.

E. Pennsylvanicus is a smaller and more fragile form; they cannot be directly compared on account of the imperfection of the material.

Formation and locality. Chemung group; Warren, Pa.

Eurypterus Pennsylvanicus.

Plate V, Fig. 18.

Eurypterus Pennsylvanicus, C. E. Hall, *Proc. Am. Phil. Soc.; Vol. VII, p. 621, 1877.*

Carapace semi-circular; length a little more than half the breadth, post-lateral angles mucronate.

Eyes situated on the anterior half of the carapace, separated by a distance equal to about one-half the breadth of the head. Midway between the eyes is a small flat node or elevation, on each side of which is a larger longitudinal prominence. There are also two similar nodes above the posterior margin. The posterior angles show two oblique short ridges. These elevations of the carapace probably indicate the positions of internal organs and the points of attachment of muscles.

The surface ornaments are not well-preserved, the specimen shows numerous small tubercles, especially over the posterior portion.

The carapace has a length of 8.5 mm. and a breadth of 15 mm.

The shape of the carapace and the arrangement of the nodes is quite different from *E. Mansfieldi*, and the geological position is considerably higher in the series than *E. Beecheri.*

Formation and locality. In an arenaceous shale; at Rooker farm, Pithole City, Venango Co., Pa.

Eurypterus Mansfieldi.

Plates IV, Figs. 1-8; V, Figs. 1-11; VI, Fig. 1; VII, Fig 1; VIII, Figs. 1-3.

Dolichopterus Mansfieldi, C. E. Hall, *Proc. Am. Phil. Soc. Philad. Vol. XVI, p. 621, 1877.*

Carapace semi-oval, nearly one-fourth broader than long; sides oblique, nearly straight; margin indented, distinctly limited. Eyes reniform, prominent, situated a little forward of the centre of the carapace and about midway between a median line and the lateral margins. Between the eyes are two broad rounded longitudinal elevations and below are two similar oblique diverging prominences.

Abdomen increasing in breadth from the carapace to the fourth segment, then gradually decreasing to the seventh segment, which is a little more than three-fourths the width of the fourth; the body narrows abruptly at the eighth segment which is about one-half the width of the fourth. The last segment is longer than wide and about one-half the width of the eighth. The posterior angles of the six anterior somites are acute and slightly produced, the seventh is considerably extended and the five posterior somites are armed with strong angular retral spines. The first segment is anchylosed to the carapace.

The telson is very narrow and attenuate; its length about one-third of the entire animal; extremity acuminate.

There are four simple palpi, of which the fourth pair project beyond the margin of the carapace for a distance equal to the width of the carapace, and expose five joints exclusive of the terminal spine. The first pair expose only the last two joints. The margins of the joints of the palpi are serrated, and the outer posterior angles are produced into spines. The palpi terminate in a long curved spine or free dactylus.

The large swimming feet near the carapace are composed of short, broad joints. The penultimate joint has a length more than twice its width. The palette is elongate elliptical in form, with the anterior terminal margin serrate. A small acute terminal plate is inserted in the apex.

The median appendage of the thoracic plate is compara-

tively very long, being six times as long as wide; the extremity is divided into four lobes, two of which form the extremity proper, while the other two are just anterior thereto. The lobes are triangular, and the anterior pair are ornamented with five or six strong plications. In the angle between the distal pair is a short process which may be the point of attachment of a small terminal appendage. Other parts of the epistoma unknown. Two of the maxillæ have been observed in position; they do not differ conspicuously from other described forms of the genus.

Metastoma ovate, bilobate at the smaller end.

Surface ornamented with minute imbricating scales. On the posterior tergal portion of each somite the scales are larger and triangular. The lateral processes of the first six segments and lateral margins of the carapace are marked by sharp, oblique striæ. The processes of the posterior segments are nearly free from ornamentation, being sometimes marked by one or two striæ. The telson appears to be free from the characteristic ornamentation of the other portions of the test. On the metastoma the scales are larger and more irregular than on the segments.

A large and nearly entire individual has the following dimensions: Extreme length from the anterior margin of the carapace to the extremity of the telson, 228 mm.; length of carapace, 31 mm.; width of fourth somite, 53 mm.; width of last somite, 15 mm.; length of telson, 80 mm. The smallest specimen observed has a length of 83 mm., of which 30 mm. belongs to the telson.

This species differs from *E. stylus*, with which it is associated, in its greater size, so far as observed, the more elongate form of the carapace, more approximate eyes, shorter palpi, and comparatively much shorter and more slender telson. The caudal spine of *E. Mansfieldi* is usually about one-third the length of the entire animal, while in *E. stylus* it occupies nearly-one half of the entire length.

E. Mazonensis, M. & W., from the coal measures of Illinois, bears a close resemblance to this species in general form and surface ornamentation, but the carapace is shorter and more regularly rounded.

The specimen represented in Fig. 1 of Plate IV is here given in outline with the metastoma and maxillæ in position. These parts can scarcely be detected on the finished drawing on account of the obscurity of the specimen, and the falsification which would result if these features were brought out conspicuously.

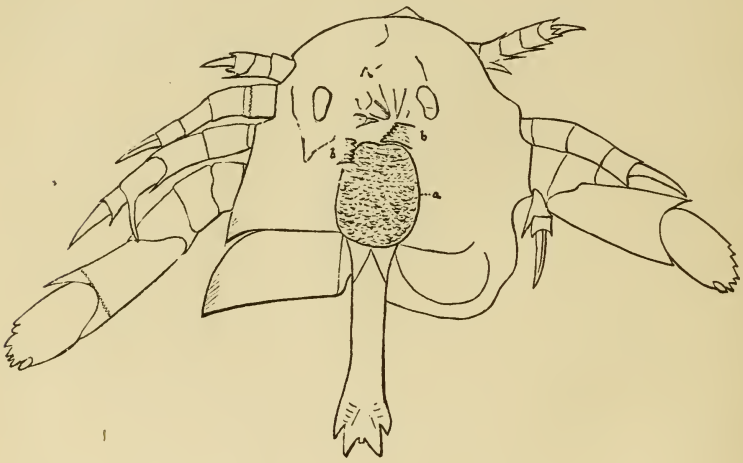


Fig. 4.—EURYPTERIS MANSFIELDI. *a.*—metastoma. *b, b.*—maxillæ.

Formation and locality.—Found in the shale immediately below the Darlington cannel coal, near Cannelton, Darlington township, Beaver county, Pennsylvania. Horizon, Alleghany river series.

EURYPTERUS STYLUS, *n. sp.*

Plate V, Figs. 12–15.

Carapace broadly semi-oval or semi-circular; length more than two-thirds the width; margin distinctly limited. Eyes situated on a line across the middle of the length of the carapace and distant about one-fourth the breadth from the margin.

Abdomen wide to the seventh segment, then abruptly narrowed and gradually decreasing in width to the telson. The first somite is anchylosed to the carapace. The widest

part of the body is across the fourth segment, which is more than three times the width of the last one.

Telson very long, having a length equal to nearly one-half the length of the entire animal.

The palpi and swimming feet are comparatively longer than in the preceding species.

Test marked by minute imbricating scales. On the posterior tergal position of the carapace and somites the scales are larger than on the other portions of the surface.

A somewhat distorted specimen has a length of 99 mm., of which 49 mm. pertain to the telson; the width of the fourth somite is 22 mm. and of the last one 7 mm.

This species is distinguished from *E. Mansfieldi* by its shorter carapace, comparatively wider body, longer and stronger telson and the eyes are more oblique and distant.

Formation and locality.—Found in the shale immediately below the Darlington cannel coal, near Cannelton, Darlington township, Beaver county, Pennsylvania. Horizon, Alleghany river series.

EXPLANATIONS OF PLATES.

PLATE III.

EURYPTERUS BEECHERI.

Page 30.

Fig. 1. Dorsal view of the specimen described, showing the form of the body, the number, size, and ornamentation of the segments, and also a portion of the large swimming appendages.
Chemung group. *Warren, Pa.*

PLATE IV.

EURYPTERUS MANSFIELDI.

Page 32.

Fig. 1. The head and first abdominal segment, with the palpi and other appendages attached. A portion of the segment and lower part of the carapace is removed showing the median appendage of the thoracic plate.

Fig. 2. A small individual, enlarged to three diameters. The palpi of the right side and telson are restored from other specimens. The lateral processes of the segments are not preserved.

Fig. 3. A specimen of the natural size, represented on a block of shale and showing the ferns and other plant remains with which it is associated.

Fig. 4. The fourth palpus of the right side enlarged to two diameters, showing the form and surface ornamentation.

Fig. 5. The second or third palpus from the right side, enlarged to two diameters.

Fig. 6. The last two joints of the large swimming foot, enlarged to two diameters.

Fig. 7. A terminal joint of one of the large swimming feet. showing the serrated margin enlarged to two diameters. The terminal plate is restored in outline.

Fig. 8. A separated metastoma, showing the form and ornamentation enlarged to two diameters.

EURYPTERUS POTENS, *n. sp.*

Fig. 9. A portion of a large ectognath.

Fig. 10. A large fragment of indeterminate relations, possibly a portion of a large ectognath. A colony of *Spirorbis* is represented on the upper right hand angle attached to some underlying substance, probably of a plant.

PLATE V.

EURYPTERUS MANSFIELDI.

Page 32.

Fig. 1. An imperfect specimen, preserving the segments of the abdomen, the telson and the large swimming appendages.

Fig. 2. A smaller individual, nearly entire, showing on the last abdominal segments what appear to be the articulating surfaces of the segments, or folds produced by the pressing together of the upper and under surfaces.

Fig. 3. A large specimen, showing the entire form. Four of the palpi are preserved, and a portion of the right swimming foot has been uncovered under the abdominal segments. The specimen being too long for the plate, the extremity of the telson is represented as broken and its continuation given above. The spinous processes at the post-lateral angles of the segments are well-preserved, and show a distinctive ornamentation.

Fig. 4. An enlargement, to six diameters, of the edge of a portion of the left lateral margin of the segments, showing the striated edge and the narrow, triangular scales with minute intermediate scales.

Fig. 5. An enlargement, to ten diameters, to show the change from the acute scales near the margin to short and more rounded forms.

Fig. 6. An enlargement from the middle of a segment, showing the minute imbricating scales along the anterior portion and large, triangular scales on the middle and lower portion. The figure represents also the posterior and anterior portions of the adjacent segments.

Fig. 7. An enlargement of the test where it is ornamented with narrow, triangular scales.

Fig. 8. Enlargement showing small and large rounded imbricating scales.

Fig. 9. A small carapace showing the characteristic elongate form of this part of the animal.

Fig. 10. The caudal spine of a small individual.

Fig. 11. A fragment of shale preserving two detached lateral processes of the segments, enlarged to two diameters.

EURYPTERUS STYLUS.

Page 34.

Figs. 12, 13. Two carapaces referred to this species, showing their form and ornamentation.

Figs. 14, 15. Two individuals of this species, showing the broad form of the body and the strong telson.

UNDETERMINED FRAGMENTS.

Fig. 16. A fragment of shale preserving several fragments of somites of undetermined specific relations.

Fig. 17. An obscure fragment, possibly a portion of an ectognath.

EURYPTERUS PENNSYLVANICUS.

Page 31.

Fig. 18. A view of the carapace described, showing its broad form, produced posterior angles and the arrangement of the nodes on the surface.

PLATE VI.

EURYPTERUS MANSFIELDI.

Page 32.

A large specimen preserving the carapace, abdomen and telson nearly entire, with three of the palpi of the left side. A portion of the test is removed along the median line exposing the process of the epistoma or median appendage of the thoracic plate. This figure shows very satisfactorily the mode of occurrence and association of these fossils.

PLATE VII.

EURYPTERUS MANSFIELDI.

Page 32.

The abdomen and telson of a specimen as it is seen lying in the shale. Heliotyped directly from a plaster cast of the specimen.

PLATE VIII.

EURYPTERUS MANSFIELDI.

Page 32.

Fig. 1. A specimen preserving the body and telson, and showing in a very perfect degree the surface sculpturing. This drawing was made from the specimen, Plate VII

Fig. 2. An imperfect individual as it is seen lying on a block of shale with some fragments of ferns and other plant remains.

Fig. 3. A separated palpus enlarged to two diameters showing the form and ornamentation of the joints. In this specimen the terminal dactylus and lateral spine are free.

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OF THE

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REPORTS FOR 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, AND 1883–1884.

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ANTHRACITE COAL FIELDS.

A. SPECIAL REPORT TO THE LEGISLATURE UPON THE CAUSES, KINDS, AND AMOUNT OF WASTE IN MINING ANTHRACITE. By Franklin Platt, Assistant Geologist, with a chapter on the METHODS OF MINING. By John Price Wetherill, Mining Engineer. Illustrated by 35 figures of mining operations, a PLAN OF THE HAMMOND COAL BREAKER, on the Girard estate, and a SPECIMEN SHEET, scale 800 feet to 1 inch, $\frac{1}{9600}$ths of nature, illustrating the PROPOSED PLAN OF MAPPING THE ANTHRACITE FIELDS. By Chas A. Ashburner, Assistant Geologist, 1881. 8 vo., pp. 134. Price, $1 10; postage, $0 12.

AC. REPORT ON THE MINING METHODS AND APPLIANCES used in the Anthracite Coal Fields. By H. M Chance: with an atlas of 25 plates; 54 plates and 60 illustrations in the text. Price, $1 40; postage, $0 25.

AC. ATLAS. Coal Mining Plates I to XXV. By H. M. Chance. Price, $1 40; postage $0 12.

AA. FIRST REPORT OF PROGRESS IN THE ANTHRACITE REGION, with a description of the Geology of the Panther Creek Basin, or Eastern End of the Southern Field. By Chas. A. Ashburner, Geologist in Charge; with an atlas of 13 sheets of maps and sections; 6 page plates, and 2 folded plates in the Report. Appendix A: Determination of the latitude and longitude of Wilkes Barre and Pottsville. By Prof. C. L Doolittle. Appendix B: Theory of Stadia Measurements, with tables. By Arthur Winslow, assistant. 1883, 8 vo., pp. xlvii and 407. Price, $0 58; postage, $0 18.

AA. ATLAS SOUTHERN ANTHRACITE FIELD, VOLUME I, PANTHER CREEK* to accompany First Report of Progress AA, 1882. Contains 13 sheets, as follows: 3 mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical sheet, and 1 coal bed area sheet, all relating to the PANTHER CREEK BASIN IN CARBON AND SCHUYLKILL COUNTIES; also, 1 miscellaneous sheet, "General Preliminary Map, Anthracite Coal Fields," and 1 miscellaneous sheet containing chart, showing total annual production of Anthracite since 1820. Chas. A. Ashburner, Geologist in Charge and A. W. Sheafer and Frank A. Hill, Assistant Geologists. Price, $1 50; postage, $0 12.

AA. ATLAS WESTERN MIDDLE ANTHRACITE FIELD, Part 1, 1884. Contains 11 sheets, as follows: 4 mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4

NOTE.—*Single sheets of the Anthracite Survey, with the exception of those in the Panther Creek atlas, can be purchased by addressing Chas. A. Ashburner, Geologist in Charge, 907 Walnut street, Philadelphia.

cross-section sheets, all relating to the Mahanoy-Shamokin Basin in Schuylkill, Columbia, and Northumberland counties. In press. Chas. A. Ashburner, Geologist in Charge, and A. W. Sheafer and Bard Wells, Assistant Geologists. Price, $; postage, $.

AA. Atlas Northern Field, Part I, 1884. Contains 6 mine sheets between Wilkes Barre and Nanticoke, 3 cross-section sheets and — columnar section sheets, all relating to the Wyoming Basin in Luzerne county. In press Chas. A. Ashburner, Geologist in Charge, and Frank A. Hill, Assistant Geologist. Price, $; postage, $.

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Q². Description of Oil Measures in and adjacent to Lawrence county. By I. C. White. (See Reports Bituminous Coal Fields.)

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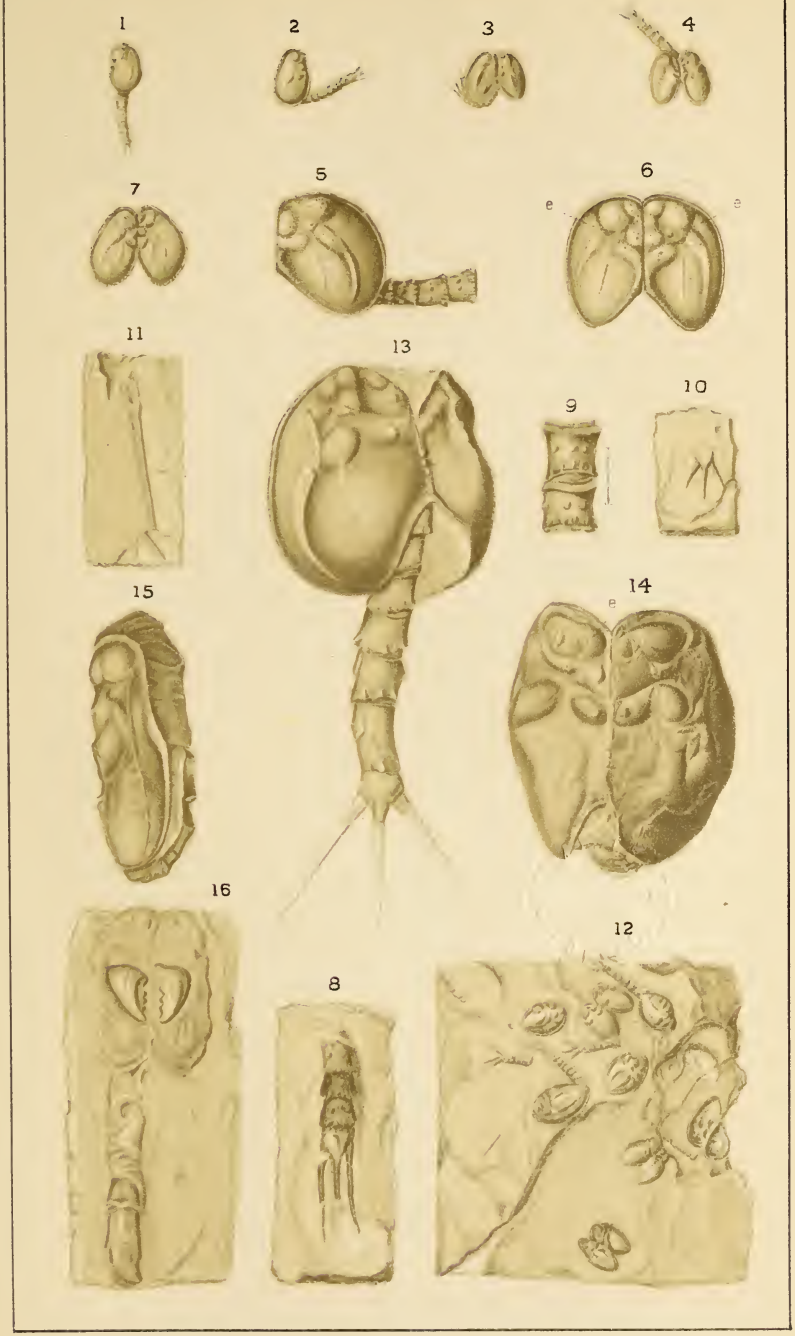

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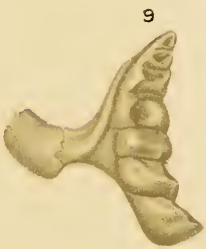

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